XIV. *Researches on the Tides.—Twelfth Series. On the Laws of the Rise and Fall of the Sea's Surface during each Tide. By the Rev.* W. Whewell, *B.D. F.R.S., Fellow of Trinity College, Cambridge.*

Received June 13,—Read June 18, 1840.

THE subject of the present communication is different in its nature from those of previous memoirs on the tides presented by me, and printed by the Society; since it refers, not to comparison of the times and heights of different tides, but to the rate of the rise and fall of the surface of the water in successive stages of the same tide. This inquiry has often been prosecuted at particular places by naval observers, and is of very material importance to navigation. For even supposing the time and height of high water to be known, it is still often requisite, for nautical purposes, to know the height of the water at a given interval before or after the moment of high water. And this inquiry may be the more useful, inasmuch as the laws of rise and fall of the surface are nearly the same at all places; the differences being, for the most part, of such a kind as can be ascertained and allowed for without much difficulty. Hence these laws, once stated, will be applicable on every coast; and the knowledge of them may supersede those laborious trains of observation which have often been instituted in order to ascertain the laws at particular places.

The materials of the present investigation (which is principally founded upon observation) are the following:—Five months' tide observations made at Plymouth, in which, besides the time and height of high and low water, the time of the surface passing two lines above the level of mean water was carefully observed; these latter observations being made, at my request, by direction of the Lords Commissioners of the Admiralty:—Three months' observations (taken out of a larger series) made at Liverpool, under the direction of Capt. Denham, R.N., in which the height of the surface was noted every half hour:—and twelve months' observations made at Bristol by Mr. Bunt, by means of his tide-gauge. The latter observations were reduced by Mr. Bunt himself; the others were discussed under my direction by Mr. Dessiou and Mr. Ross, of the Hydrographer's Office, with their usual care and skill.

Whatever be the exact law of the rise and fall of the tide, if the rise and fall be nearly symmetrical (which it usually is), the height of the surface of the water at a given place will increase nearly as the sine, while the time increases as the arc. Hence, if we were to make the time the *abscissa* and the height the *ordinate*, we should obtain (for one tide) the *figure of sines* for our curve. Or, to put the matter otherwise: if we suppose a point to move uniformly through the circumference of a circle in a tidal

half-day, the height of this point above a horizontal line will represent the height of the surface of the water, supposing the velocity and the radius to be duly adjusted.

But the radius depends upon the total rise of the surface, and the velocity depends on the length of a tidal day, and both these quantities are different at different periods of a lunation. Hence our line of sines will, even theoretically, require some modification.

Let the height of the surface above a given *zero* line be

$$y = k + h \cos \frac{2 \pi t}{\tau},$$

where τ is the length of the tidal half-day, and t the time from high water; $2h$ the rise from low water to high water.

The quantity τ will (according to theory) differ at different periods of the semilunation. The law of its change is determined as follows:

Let ϕ be the R.A. of the moon *minus* a certain constant, and θ the time at which the high water (or low water) follows the moon's transit, *minus* a certain other constant; c the ratio of the solar to the lunar tide. Then by the equilibrium theory we have

$$\tan 2\theta = -\frac{c \sin 2\phi}{1 + c \cos 2\phi}.$$

Also if ϕ', θ', be the values of ϕ, θ, at the next tide,

$$\tan 2\theta' = -\frac{c \sin 2\phi'}{1 + c \cos 2\phi'}.$$

Hence $\tan (2\theta' - 2\theta) = -\dfrac{c(\sin 2\phi' - \sin 2\phi) + c^2 \sin 2(\phi' - \phi)}{1 + c(\cos 2\phi' + \cos 2\phi) + c^2}$

$$= -\frac{c \cos(\phi' + \phi) + c^2 \cos(\phi' - \phi)}{1 + 2c \cos(\phi' + \phi) \cos(\phi' - \phi) + c^2} \cdot 2 \sin(\phi' - \phi).$$

But the arcs $2\theta' - 2\theta$ and $\phi' - \phi$ are small, and very nearly as their tangents and sines. Also $\cos(\phi' - \phi) = 1$, nearly, and $\cos(\phi' + \phi) = \cos 2\phi$, nearly.

Hence $\theta' - \theta = -(\phi' - \phi) \dfrac{c \cos 2\phi + c^2}{1 + 2c \cos 2\phi + c^2}$,

whence $\theta' - \theta + \phi' - \phi = \dfrac{1 + c \cos 2\phi}{1 + 2c \cos 2\phi + c^2}(\phi' - \phi)$.

Now the former tide happens $\phi + \theta$ after the sun's transit, and the latter tide $\phi' + \theta'$ after the sun's next transit; therefore the length of the tidal half-day is $12^h + \theta' + \phi' - \theta - \phi$. Also $\phi' - \phi$ is constant, being always very nearly 24 minutes. Hence the tidal half-day will be least and greatest when the above fraction is so; that is, when 2ϕ is 0 and π. The tidal half-day is therefore least at spring tides, when it is

$$12^h + \frac{\phi' - \phi}{1 + c};$$

and greatest at neap tides, when it is

$$12^h + \frac{\phi' - \phi}{1 - c}.$$

FIG. 1. — LIVERPOOL. — CURVES OF RISE AN

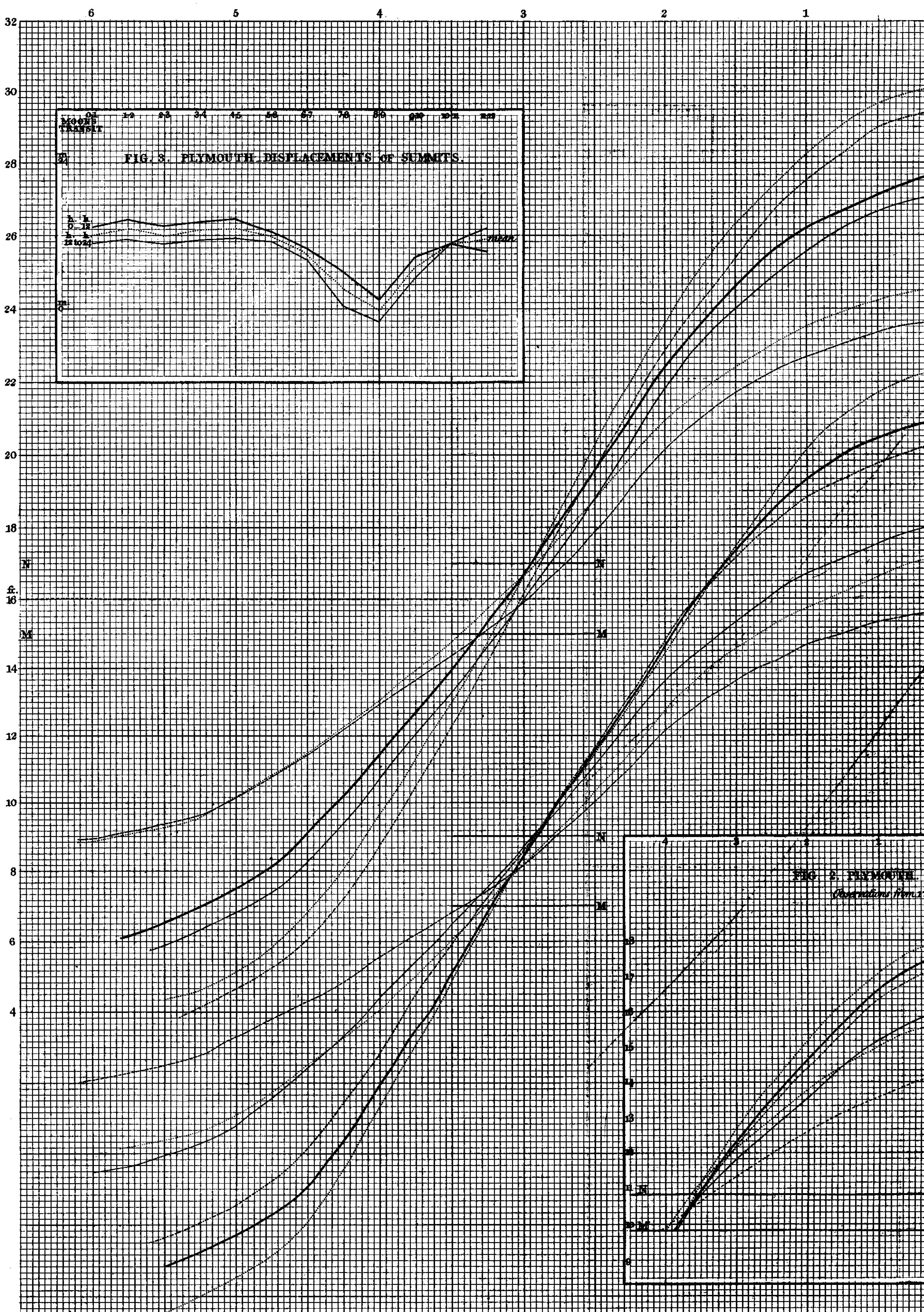
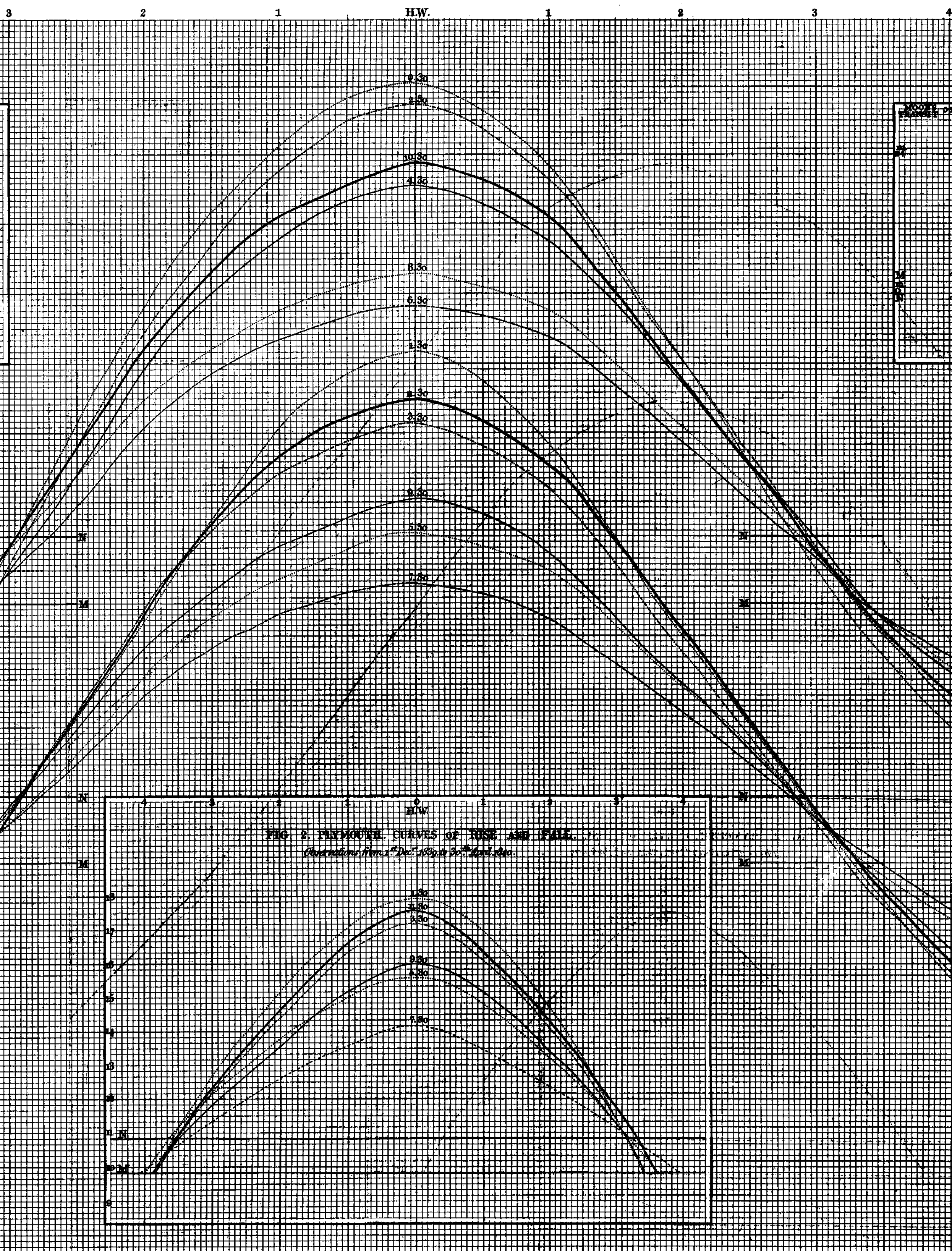


FIG. 1. — LIVERPOOL. — CURVES OF RISE AND FALL. — OBSERVATIONS FROM AUG.ST 1.ST TO OCT.R 18.TH 1840.



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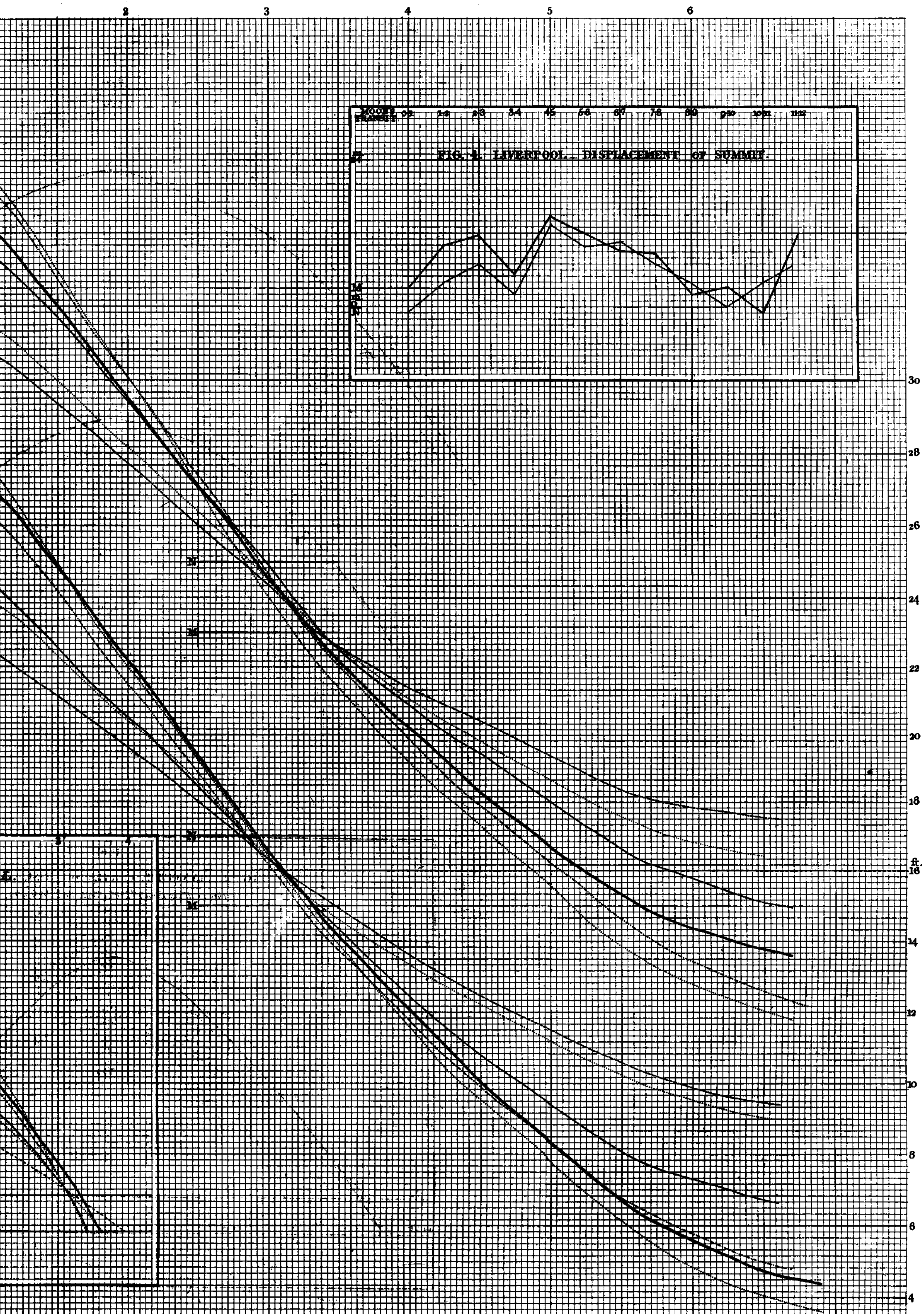
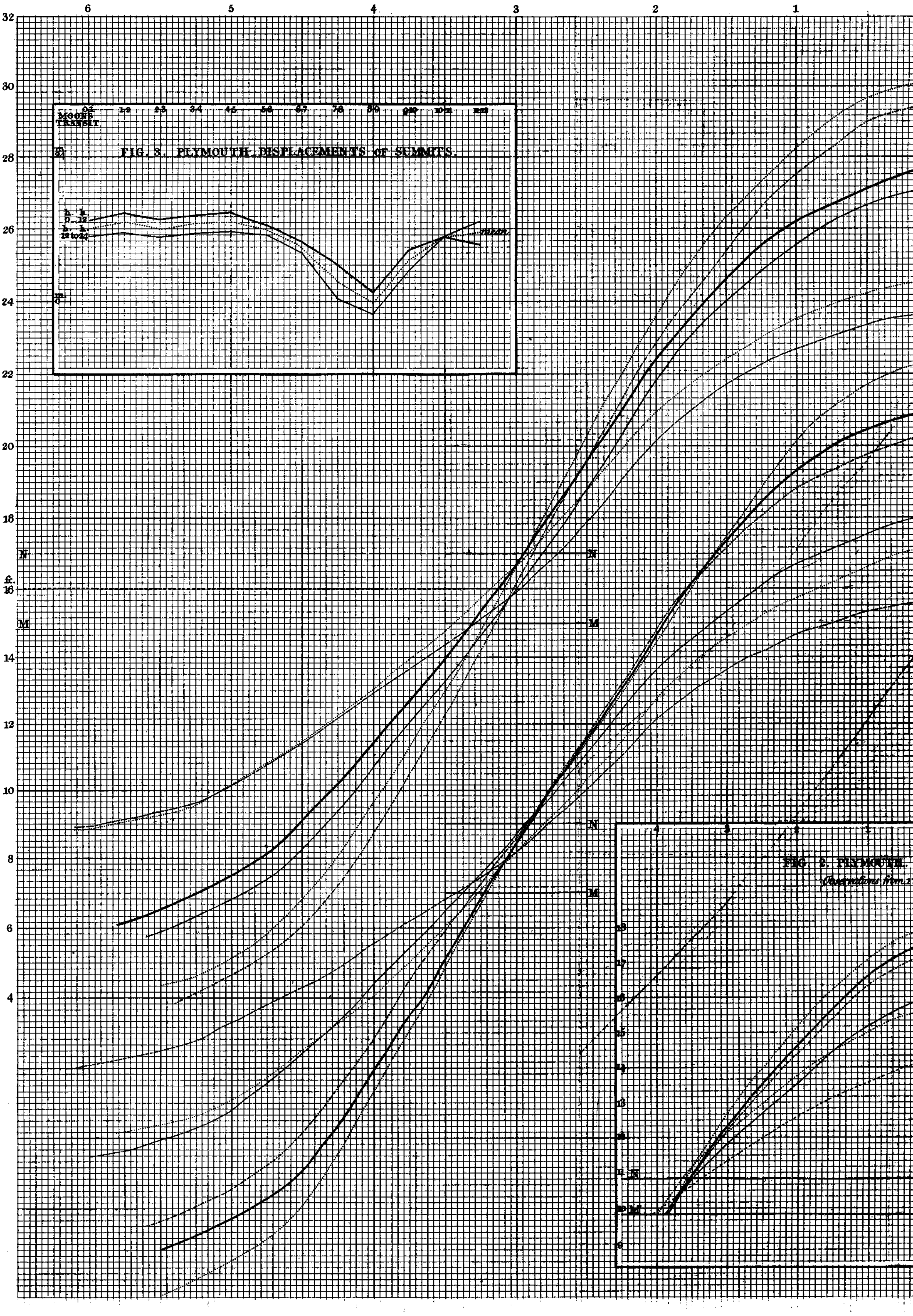
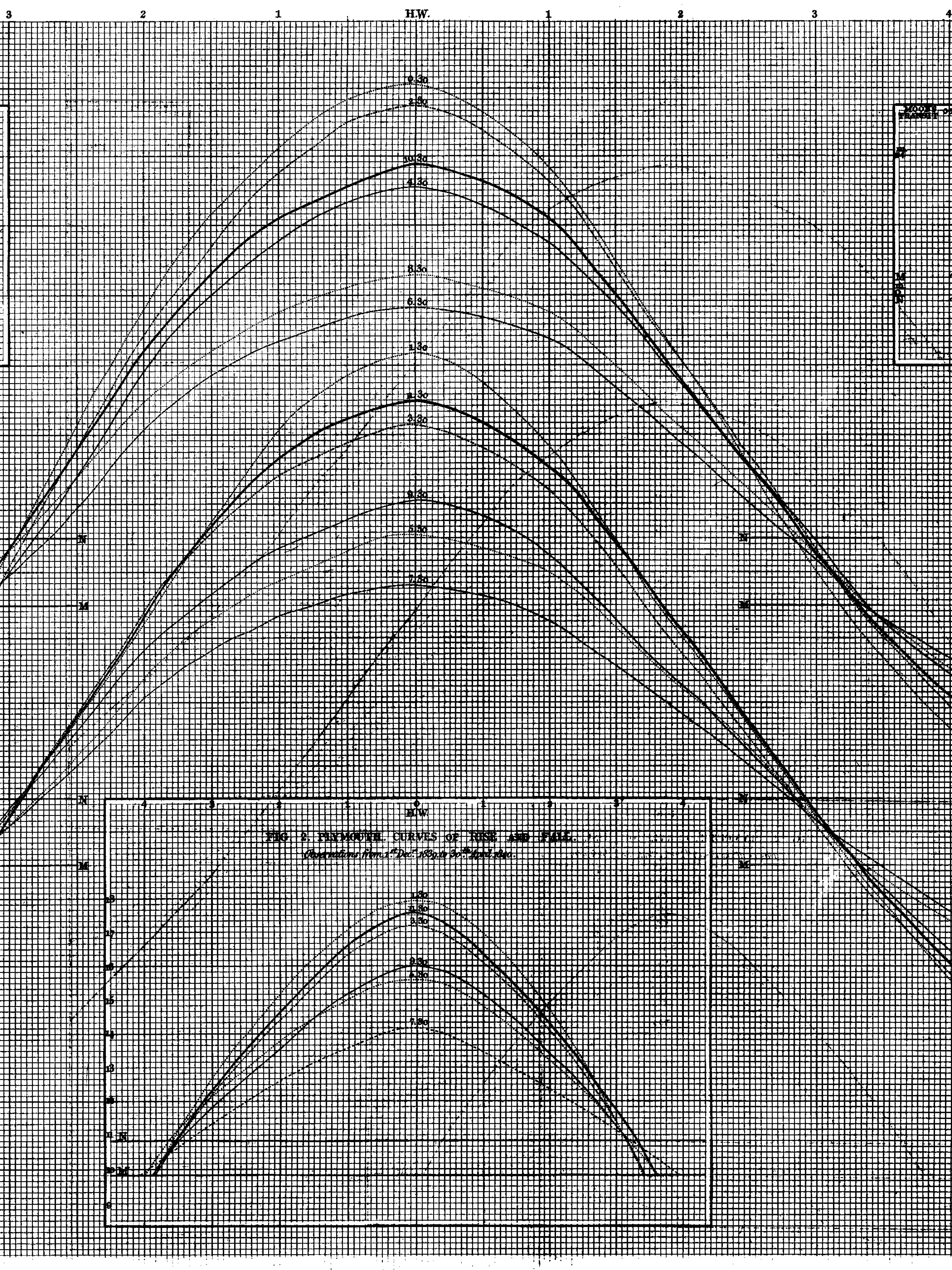


FIG. 1. — LIVERPOOL. — CURVES OF RISE AN



G. 1. — LIVERPOOL. — CURVES OF RISE AND FALL. — OBSERVATIONS FROM AUGST 1ST TO OCT^{R} 18TH 1840.



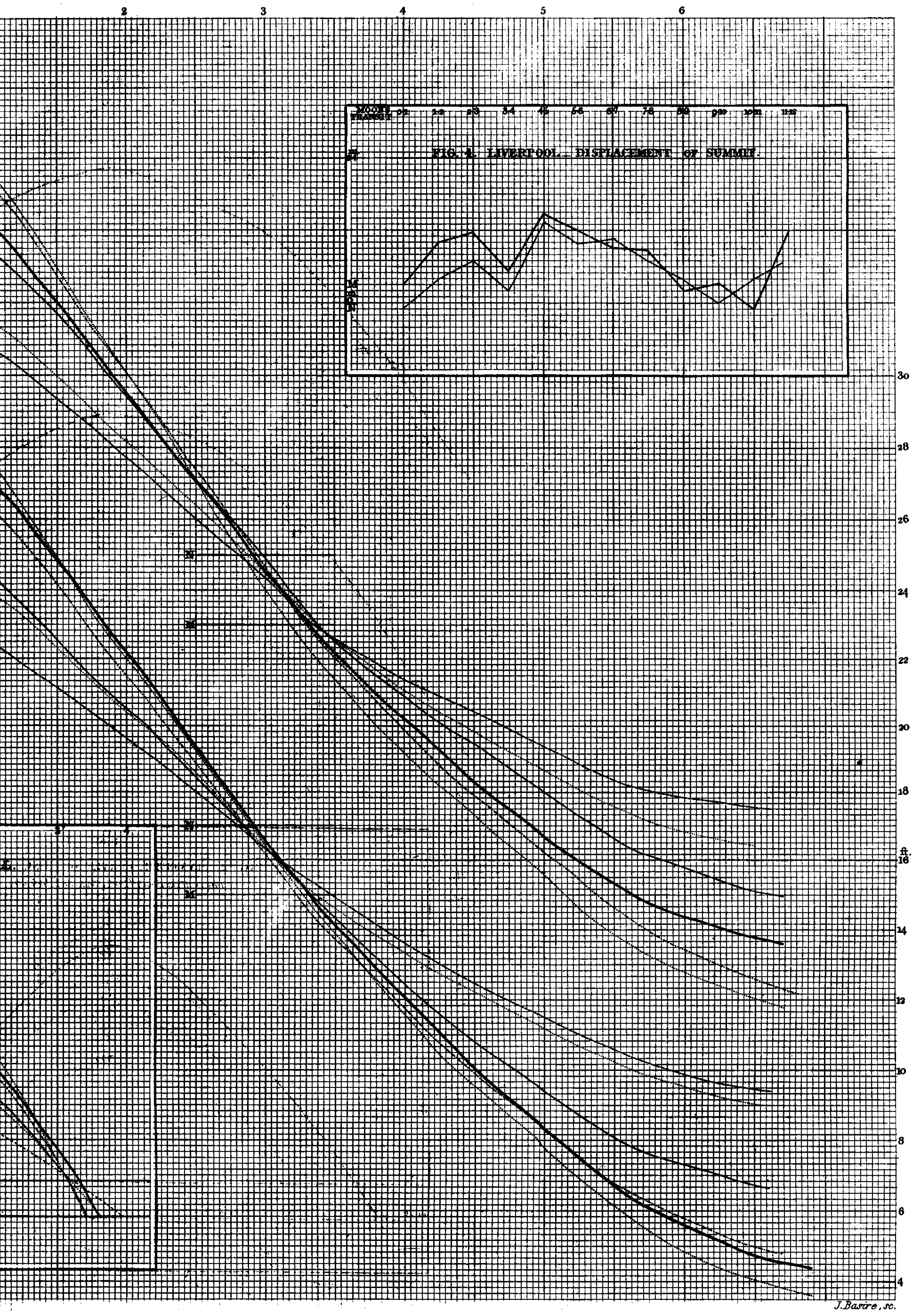

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FIG. 4. LIVERPOOL _ DISPLACEMENT OF SUMMIT.
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4
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M
J.Basire, sc.

If we take $\varphi' - \varphi$ to be 24 minutes, and c to be $\frac{2}{5}$, which is the value which agrees best with the times at Plymouth, these tidal half-days are respectively $12^h\ 17^m$ and $12^h\ 40^m$. At any other time

$$\tau = 12^h + 24^m \frac{1 + c \cos 2\varphi}{1 + 2c \cos 2\varphi + c^2} = 12^h \left\{ 1 + \frac{1}{30} \cdot \frac{1 + c \cos 2\varphi}{1 + 2c \cos 2\varphi + c^2} \right\}.$$

The height, $2h$, of the total tide varies with the period of the lunation. If $2H$ be the total lunar tide,

at springs $h = H(1 + c')$.

at neaps $h = H(1 - c')$.

at any time $h = H\sqrt{\{1 + 2c' \cos 2\varphi + c'^2\}}$;

but c' has no longer at all places the same value as c before. The Liverpool tides give $\frac{2}{5}$ as the value of c': but in order to satisfy the Plymouth observations of height, c' must be about $\frac{1}{4}$.

Since the curve of rise and fall at spring tides has its amplitude the smallest and its ordinate the largest, it will intersect all the others. The points of intersection will be a little above mean water.

We have now to inquire whether these features appear in the empirical laws of the tides, as collected from discussion of the observations already spoken of: namely, whether the curve of rise and fall is the figure of sines, and whether its maximum ordinate (h) and its amplitude (τ) follow laws resembling those given by the theory. If this is the case, the intersections of the curves will also agree with the theory.

(1.) The empirical curve of rise and fall agrees very nearly with the figure of sines at all the three places here considered. The figure was determined differently at the different places. At Liverpool, where the height of the water was observed every half hour, the total curve was given empirically, and is exhibited in Plate X. fig. 1., the curves being thrown into two groups (according to hours of moon's transit) to avoid confusion. At Plymouth, the time and height of high water were observed, and also the time of passing two horizontal lines (M and N) situated near mean water (at nine feet ten inches and ten feet ten inches respectively, above the zero of the scale). By this means five points were given in each curve, (the observations being arranged according to the hour of transit), and the curves were drawn by the eye through these points, as may be seen in fig. 2.

At Bristol, the tide-gauge did not allow the rise and fall to be observed more than half way down from high water to mean water; but there is no doubt that in its general law of variation, the curve approached nearly to the figure of sines.

(2.) But in all these cases, more or less, there is a deviation of the empirical from the theoretical form, which deserves notice. Instead of being a symmetrical curve,

the rise and the fall taking place at the same rate, the empirical curve of rise and fall is unsymmetrical, the fall being more rapid than the rise in general, though sometimes the reverse occurs. By this means the *summit* of the curve of rise and fall is *displaced*, and is posited to the right or left of the position given by *bisecting the interval* of the times at which the surface, in rising and in falling, passes some lower line (as the line of mean water). This *displacement of the summit* I have taken at Liverpool for two lines (M and N) at the heights of fifteen feet and seventeen feet above the zero; at Plymouth for two lines (M and N) which, as above stated, are at nine feet ten inches and ten feet ten inches above the zero. In these cases the lines M and N are very near *mean water*. At Bristol, as I have said, the lower observed height was half way from mean water to high water.

The displacement of the summit being arranged according to the hour of moon's transit, there is no obvious agreement in the form of the result for different places. Fig. 3. and 4. give the curves which express these results for Plymouth and Liverpool; Bristol is not readily comparable with these, from the nature of the observations.

(3.) The variations in the length of the *tidal half-day* (from low water to low water) were also examined. It appeared that at Liverpool and at Plymouth the variations in this element followed nearly the law indicated by the theory; which, indeed, may be considered as having been previously sufficiently proved by the near accordance of the observed with the theoretical times of high and low water; an accordance which had already been established by the discussion of the observations at Liverpool, London, and other places.

(4.) The same may be said of the variations in the height of high and low water during a semilunation. It had already been repeatedly shown, that (if we assume a proper value of c) these, as observed, agree with great accuracy with the theory, at every place yet examined.

(5.) Hence, as I have said, the intersections of the curves of rise and fall belonging to different hours follow, in the curves given by observations, nearly the theoretical law. Thus these intersections all take place nearly at mean water; but occur a little higher and nearer high water than the height and time of mean water.

(6.) But yet the want of exact symmetry in the empirical curves occasions some peculiar features in the intersections of these curves. Thus, at least for many of the hours of transit, the intersections of the curves of rise and fall are higher and nearer the time of high water in descending than in ascending. This may be seen in the Liverpool curves, in which many of the ascending intersections fall very near the line M, while the corresponding descending intersections fall near the line N.

(7.) Since the time of ascending is greater, and the height ascended less, at neaps than at springs, it is plain that the velocity of ascent must be greater, and the time of ascending a given space less, at springs than at neaps. The same is the case of descent. And hence the times of ascending from M to N vary, and this variation appears eminently in the rate of the surfaces ascending or descending about mean

water. I have compared the times of ascending a given space (from M to N) both at Liverpool and at Plymouth, but I have not thought it necessary to give the diagram which exhibits the result.

(8.) Near mean water the surface is rising or falling with the greatest velocity. Hence the observation of the time at which the surface passes the line M or N is far more precise than the observation of high and low water. The observations at Plymouth were made *to seconds*; and the hypothetical time of high water, obtained by bisecting the interval from M rising to M falling, agreed with the time obtained by bisecting the interval between N rising and N falling, generally within a minute or two, and often within a few seconds.

(9.) Since this is the case, it might be made a question, whether it would not be better to observe the time of the surface passing M, or N, or both, than to observe the time of high water and low water. (Of course it must be understood, that it would still be requisite to observe the *height* of high water and low water, but this is very easily done, either by the eye, or by self-registering machinery.) There are some circumstances which appear to confirm the conjecture that this would be an improvement in tide observations: for instance, the *diurnal inequality* of the times of high water at Plymouth is much more distinctly seen in the bisected times than in the observed times; but on examining the general run of the observations, it does not appear that the bisected times are more regular than the observed times.

Since the exactness with which it is possible to determine the bisected time of high water has not previously been practically shown, I shall give, at the end of this memoir, the comparison of the bisected times obtained from the lines M and N at Plymouth, with each other, and with the observed times of high water.

(10.) As we have already seen, the displacement of the summit of the curves of rise and fall, that is, the time by which the observed time of high water differs from the bisected time, appears to follow different laws at different places, and therefore probably depends upon local circumstances. In general, in the cases hitherto examined, the observed time is later than the bisected time; that is, the surface descends more rapidly than it rose. But both at Liverpool and Plymouth this difference vanishes very nearly at about seven hours' transit. Thus at neap tides the curve of rise and fall is nearly symmetrical.

(11.) The laws which we have investigated have been referred to the hours of the moon's transit, these hours being reckoned from 1 to 12; but at Plymouth, if we refer the observations to hours of moon's transit from 1 to 24, thus distinguishing superior from inferior transits, we find a great difference in the effects belonging to corresponding transits, as 6^h and 18^h, 7^h and 19^h, and the like. This difference apparently arises from a diurnal inequality, and would disappear when the moon's nodes came into another position.

London, June 12, 1840.

P.S. I will add to the above memoir two tables, giving the height of the surface of the sea at any time, as affected by the tide at Plymouth and at Liverpool. In constructing these tables I have supposed the rise and fall of the surface to follow the law of the sine of the time from mean water, as already explained. For although there exists in many places a *displacement of the summit* of the curve of rise and fall, this displacement is small, and would not much affect the height at any time. Whether it arise from the combination of the solar with the lunar tide-wave, or of the diurnal with the semidiurnal wave, or from the form of the channel and local circumstances, it may be disregarded or postponed in a statement like the present.

The height is given in these tables according to hours *before* and *after* high water, the curve being supposed symmetrical, as we have said. The *unit* of height (expressed in the table by 1000) is the height of the high water at spring tides above the *mean water*, or half the total rise of the surface at spring tides. The table must be adapted to any particular place by multiplying each tabular number by this quantity (the height of spring tide high water above mean water) for the place (cutting off three decimal places).

The highest spring tides and the lowest neap tides take place at different intervals after the moon's syzygies and quadratures at different places, the interval varying from a few hours to a few days. In like manner the tides *corresponding* to the moon's *octants* (when her transit takes place three hours after the sun's) follow the time of the octants at different intervals at different places; but they may be very intelligibly designated as *octant tides*, which term is employed in the tables.

In the table for Plymouth, the spring tide is to the neap tide as 5 to 3; which supposes the solar tide to be *one fourth* of the lunar tide. In the table for Liverpool, the spring tide is to the neap tide as 7 to 3; which supposes the solar tide to be *two fifths* of the lunar. These are the proportions given by observation at those places.

I will add an *Example* of the use of the following tables. Let it be proposed *to find the height of the surface at Plymouth* $1\frac{3}{4}$ *hour before high water at octant tides.* The range of spring tides at Plymouth is sixteen feet; hence the unit of heights is eight feet; and at $1\frac{3}{4}$ hour before high water the tabular number (by interpolation) is ·515. Hence the height above mean water is 4·12 feet, or four feet one inch; and since mean water is at nine feet ten inches on the scale, the height of the surface on the scale is thirteen feet eleven inches at the time proposed.

Tables of the Elevation or Depression of the Surface of the Sea above or below Mean Water at all hours of the Tide.

For Plymouth.

	Before or after High Water.	Spring Tides.	Octant Tides.	Neap Tides.
	h m			
Above mean water.	0 0	1000	825	600
	0 30	979	797	584
	1 0	872	721	530
	1 30	720	599	441
	2 0	522	432	330
	2 30	289	245	194
	3 0	041	038	047
Below.	3 30	217	172	100
	4 0	462	367	243
	4 30	665	541	371
	5 0	834	679	470
	5 30	945	772	550
	6 0	996	818	592
Low water..		1000	825	600
		h m	h m	h m
Time		6 8	6 11	6 20

At $2^h\ 52^m$ before and after high water, the surface, both at neaps and springs, is 57 of the parts above mean water, that is $\frac{2}{35}$th of the tidal unit.

For Liverpool.

	Before or after High Water.	Spring Tides.	Octant Tides.	Neap Tides.
	h m			
Above mean water.	0 0	1000	775	429
	0 30	979	748	417
	1 0	872	677	379
	1 30	720	562	315
	2 0	522	405	236
	2 30	289	230	139
	3 0	041	635	033
Below.	3 30	217	161	071
	4 0	462	344	174
	4 30	665	508	265
	5 0	834	637	336
	5 30	945	725	393
	6 0	996	768	423
Low water..		1000	775	429
		h m	h m	h m
Time		6 9	6 11	6 19

Observations at Plymouth of the time when the Surface passes lines M and N; and the calculated Time of High Water, hence obtained, compared with the Observed Time.

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1839.	h m s	h m s	h m s	h m s	h m s
December 1	5 34 23		5 2 20		
	10 7 45		10 31 26		
	5 51 47	1 59 46	5 26 34	1 59 0	1 45 0
	10 47 25		11 10 54		
2	6 25 55	2 36 40	6 1 36	2 36 15	2 13 0
	10 47 57		11 18 50		
	6 40 30	2 44 13	6 15 51	2 47 20	2 41 0
	11 30 3		11 51 13		
3	7 3 10	3 16 36	6 40 42	3 15 58	3 2 0
	11 49 49				
	7 17 58	3 33 54	0 9 38		
			6 57 40	3 33 39	3 28 0
4	0 16 10		0 35 21		
	7 44 3	4 0 6	7 22 10	3 58 46	3 50 0
	0 31 39		0 50 29		
	7 54 0	4 12 50	7 32 30	4 12 0	4 9 0
5	0 55 5		1 16 10		
	8 11 54	4 33 30	7 51 13	4 33 41	4 27 0
	1 23 16		1 41 37		
	8 21 31	4 52 24	8 0 34	4 51 6	4 45 0
6	1 34 15		1 58 20		
	8 50 24	5 12 20	8 31 27	5 14 53	5 4 0
	1 51 24		2 8 47		
	9 8 50	5 30 7	8 48 45	5 28 46	5 25 0
7	2 5 50		2 17 54		
	9 34 22	5 50 6	9 17 39	5 47 47	5 39 0
	2 23 6		2 40 24		
	9 41 30	6 2 18	9 21 20	6 0 52	6 0 0
8	2 36 24		2 54 53		
	10 5 15	6 20 50	9 47 50	6 21 11	6 11 0
	3 1 52		3 19 15		
	10 16 0	6 38 56	9 55 55	6 37 35	6 32 0
9	3 9 30		3 24 24		
	10 37 28	6 53 29	10 18 19	6 51 22	6 50 0
	3 31 57		3 49 27		
	10 56 25	7 14 11	10 33 14	7 11 22	7 7 0
10	3 25 32		3 51 26		
	11 24 23	7 24 58	11 3 28	7 27 27	7 27 0
	3 59 40		4 20 23		
	11 37 22	7 48 36	11 14 6	7 47 15	7 44 0
11	4 1 20		4 22 0	8 6 14	8 1 0
		8 6 30	11 50 27		
	0 11 39				
	4 24 45		4 45 20		
12	0 30 20	8 27 33	0 5 15	8 25 18	8 18
	4 14 10		4 38 50		
	1 6 56	8 40 33	0 45 24	8 42 7	8 42 0
	5 8 10		5 32 35		
13	1 23 30	9 15 50	1 0 10	9 16 22	9 6 0
	5 15 5		5 40 0		
	1 58 5	9 36 35	1 32 11	9 36 6	9 30 0
	6 4 15		6 30 3		
14	2 25 5	10 14 40	1 52 0	10 11 2	9 50 0
	6 16 9		6 41 20		
	2 48 28	10 32 19	2 18 7	10 29 14	10 19 0
	7 27 9		7 55 25		
15	3 24 10	11 25 40	2 55 14	11 25 20	10 47

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1839.	h m s	h m s	h m s	h m s	h m s
December 15	3 24 10		2 55 14		
	7 32 40	11 49 20	7 58 5	11 46 13	11 30 0
	4 5 0		3 34 20		
	8 22 10	0 25 12	8 51 40	0 25 10	11 59 0
16	4 27 15		3 58 40		
	8 50 55	0 48 10	9 18 46	0 51 58	0 39 0
	4 45 25		4 25 10		
	9 50 45	1 39 0	10 14 0	1 39 15	1 9 0
17	5 27 15		5 4 30		
	10 8 19	2 11 57	10 26 49	2 10 20	1 45 0
	6 15 35		5 53 50		
	10 41 45	2 44 49	10 59 40	2 44 28	2 20 0
18	6 47 52		6 29 16		
	11 6 17	3 9 44	11 24 22	3 9 36	2 54 0
	7 13 10		6 54 50		
	11 50 41				
19		3 44 20	0 7 10	3 43 45	2 26 0
	7 37 59		7 20 20		
	0 17 41	4 15 14	0 35 38	4 11 57	3 36 0
	8 12 46		7 48 15		
20	0 41 54	4 42 21	0 53 52	4 40 35	4 21 0
	8 42 48		8 27 18		
	1 11 41	5 8 36	1 26 22	5 8 31	4 48 0
	9 5 30		8 50 40		
21	1 25 10	5 26 27	1 49 15	5 31 47	5 16 0
	9 27 44		9 14 19		
	2 8 12	6 2 10	2 22 3	6 2 11	5 40 0
	9 56 8		9 42 19		
22	2 29 15	6 26 28	2 42 30	6 26 57	6 17 0
	10 23 40		10 11 25		
	2 55 23	6 54 2	3 10 35	6 53 20	6 33 0
	10 53 41		10 36 4		
23	3 13 40	7 11 11	3 25 20	7 11 24	7 2 0
	11 8 41		10 57 28		
	3 43 10	7 44 50	3 57 45	7 43 17	7 25 0
	11 46 30		11 28 50		
24	3 44 47		3 56 17	7 52 17	7 48 0
		7 53 42	11 48 16		
	0 2 36				
	4 10 10	8 13 37	4 33 5	8 17 41	8 5 0
25	0 17 4		0 2 17		
	4 34 40	8 34 33	4 56 30	8 36 19	8 26 0
	0 34 25		0 16 8		
	5 15 45	9 4 31	5 32 5	9 2 18	8 45 0
26	0 53 16		0 32 30		
	5 16 52	9 25 37	5 34 2	9 23 32	9 11 0
	1 34 21		1 13 2		
	5 34 22	9 46 1	5 52 7	9 40 11	9 30 0
27	1 57 40		1 28 15		
	5 49 43	10 1 53	6 9 23	9 59 26	9 53 0
	2 14 2		1 49 28		
	6 24 29	10 32 38	6 48 38	10 29 29	10 12 0
28	2 40 46		2 10 20		
	6 35 22	10 46 32	6 59 15	10 42 18	10 34 0
	2 57 42		2 25 20		
	7 25 20	11 25 20	7 54 30	11 22 40	10 52 0
29	3 25 20		2 50 50		

Table. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
	h m s	h m s	h m s	h m s	h m s
1839. December 29	3 25 20		2 50 50		
	7 27 30	11 42 51	7 59 30	11 40 38	11 25 0
	3 58 12		3 21 45		
	8 15 30	0 23 10	8 49 15	0 21 30	11 47 0
30	4 30 50		3 53 45		
	8 32 16	0 41 39	9 5 10	0 40 57	0 14 0
	4 51 2		4 16 44		
	9 32 34	1 5 4	10 4 38	1 2 59	0 48 0
31	4 37 33		4 1 20		
	9 49 43	1 51 27	10 21 8	1 53 26	1 21 0
	5 53 30		5 25 45		
1840.	10 31 40	2 37 25	11 9 51	2 39 6	2 4 0
January 1	6 43 10		6 8 20		
	10 52 4	3 0 22	11 19 8	3 2 11	2 33 3
	7 8 40		6 45 15		
	11 10 20	3 21 33	11 35 40	3 22 59	3 3 0
2	7 32 45		7 10 18		
	11 57 51				3 28 0
		3 43 58	0 21 39	3 43 25	3 58 0
	7 30 5		7 5 10		
3	0 34 45	4 16 38	0 55 8	4 14 37	4 27 0
	7 58 30		7 34 6		
	0 57 22	4 36 33	1 17 2	4 35 52	4 51 0
	8 15 43		7 54 41		
4	1 3 52	4 54 24	1 22 21	4 53 51	5 5 0
	8 44 56		8 25 21		
	1 27 41	5 15 28	1 46 11	5 13 51	5 30 0
	9 3 15		8 41 30		
5	1 40 25	5 31 3	2 5 37	5 34 59	5 48 0
	9 21 40		9 4 20		
	2 17 30	5 53 58	2 36 3	5 54 20	6 11 0
	9 30 25		9 12 37		
6	2 28 21	6 12 28	2 43 42	6 11 41	6 29 0
	9 56 34		9 39 40		
	2 51 27	6 30 51	3 6 34	6 29 27	6 45 0
	10 10 15		9 52 20		
7	3 3 4	6 46 19	3 19 5	6 46 12	7 0 0
	10 29 34		10 13 18		
	3 32 30	7 7 35	3 50 41	7 7 11	7 18 0
	10 42 39		10 23 40		
8	3 39 5	7 20 26	3 56 9	7 20 45	7 36 0
	11 1 47		10 45 21		
	4 11 45	7 42 0	4 28 59	7 41 43	7 53 0
	11 12 16		10 54 26		
9	4 21 37	7 58 52	4 38 23	7 58 37	8 19 0
	11 36 7		11 18 51		
	4 53 5	8 19 47	5 11 12	4 18 38	8 36 0
	11 46 28		11 26 4		
10	5 2 18		5 20 7	8 37 34	8 57 0
		8 37 51	11 55 0		
	0 13 23				
	5 37 5	9 1 39	5 56 41	9 1 13	9 10 0
11	0 26 12		0 5 45		
	5 34 15	9 15 19	6 1 25	9 18 22	9 36 0
	0 56 23		0 35 18		
	6 19 33	9 48 4	6 38 42	9 43 26	9 55 0
12	1 16 34		0 48 10		

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
January 12	1 16 34		0 48 10		
	6 19 45	10 6 28	6 37 10	10 3 38	10 24 0
	1 53 11		1 30 5		
	6 40 16	10 29 45	7 2 10	10 28 40	10 45 0
13	2 19 13		1 55 10		
	7 0 10	11 3 46	7 21 16	11 2 30	11 17 0
	3 7 23		2 43 44		
	7 40 5	11 35 7	8 0 10	11 34 47	11 43 0
14	3 30 10		3 9 24		
	8 16 30	0 11 12	8 41 3	0 9 55	0 22 0
	4 5 55		3 38 46		
	9 7 18	1 2 17	9 37 17	1 0 1	0 54 0
15	4 57 16		4 22 45		
	9 41 42	1 38 11	10 6 10	1 36 58	1 43 0
	5 34 40		5 7 45		
	10 16 15	2 11 13	10 46 13	2 14 46	2 20 0
16	6 6 10		5 43 20		
	11 17 28	3 0 22	11 42 47	3 0 33	3 3 0
	6 43 16		6 18 20		
	11 29 30	3 29 55	11 50 20	3 30 25	3 42 0
17	7 30 20		7 10 30		
	0 5 42	3 57 14	0 25 19	3 57 45	4 20 0
	7 48 45		7 32 12		
18	0 46 10	4 31 28	1 2 15	4 30 43	4 43 0
	8 16 45		7 59 10		
	1 25 38	5 5 6	1 39 12	5 3 51	5 12 0
	8 44 34		8 28 30		
19	1 45 21	5 35 26	2 2 40	5 35 25	5 37 0
	9 25 30		9 8 10		
	2 9 50	5 51 50	2 23 25	5 51 28	6 14 0
	9 33 50		9 19 30		
20	2 27 40	6 13 0	2 43 30	6 14 32	6 24 0
	9 58 21		9 45 34		
	3 3 0	6 46 38	3 14 44	6 45 37	6 55 0
	10 30 15		10 16 30		
21	3 10 25	6 59 34	3 24 43	6 59 36	7 15 0
	10 48 42		10 34 30		
	3 53 40	7 25 55	4 7 45	7 22 30	7 31 0
	10 58 9		10 37 15		
22	3 54 11	7 38 19	4 11 41	7 40 46	7 56 0
	11 22 26		11 9 51		
	4 27 10	8 1 25	4 42 48	8 2 42	8 4 0
	11 35 39		11 22 36		
23	4 31 28	8 16 4	4 45 50	8 15 52	8 24 0
			11 45 54		
	0 0 41		5 13 20	8 30 56	8 49 0
	4 55 15	8 35 18	11 48 32		
24	0 15 21		5 16 40		
	4 56 50	8 58 31		9 1 35	9 4 0
	1 0 12		0 46 29		
	5 6 30	8 59 50	5 19 45	9 0 3	9 13 0
25	0 53 10		0 40 20		
	5 28 32	9 16 19	5 48 15	9 15 12	9 30 0
	1 4 6		0 42 8		
	5 56 15	9 52 15	6 17 19	9 50 14	9 47 0
26	1 48 15		1 23 8		

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
January 26	1 48 15		1 23 8		
	5 27 6	9 45 35	5 46 16	9 42 36	10 10 0
	2 4 3		1 38 55		
	6 11 20	10 18 55	6 47 15	10 21 15	10 24 0
27	2 26 30		1 55 16		
	6 32 45	10 36 24	6 58 25	10 32 45	10 43 0
	2 40 3		2 7 6		
	6 54 5	11 18 7	7 27 33	11 4 22	11 0 0
28	3 42 10		2 41 12		
	6 19 50	11 19 30	7 7 45	11 23 28	11 34 0
	4 19 10		3 39 11		
	6 49 56	0 2 0	7 54 50	0 3 29	0 35 0
29	5 14 5		4 12 8		
	8 27 17	0 55 51	9 27 32	1 1 36	1 7 0
	5 24 25		4 35 40		
	9 19 38	1 34 24	10 3 7	1 33 6	1 26 0
30	5 49 10		5 3 5		
	10 18 6	2 39 33	10 49 46	2 36 15	2 3 0
	7 1 0		6 21 45		
	10 32 35	2 45 30	11 0 25	2 44 13	2 45 0
31	6 58 25		6 28 0		
	11 30 30	3 22 58	11 57 50	3 24 10	3 30 0
	7 15 25		6 50 30		
	11 42 35				
February 1		4 4 27	0 2 0	4 4 16	3 46 0
	8 26 18		8 6 32		
	0 2 31	4 4 26	0 23 14	4 2 22	4 28 0
	8 6 25		7 41 30		
2	0 40 35	4 35 58	1 2 39	4 37 4	4 48 0
	8 31 20		8 11 30		
	1 10 8	5 10 14	1 29 4	5 9 35	5 17 0
	9 10 20		8 50 5		
3	1 12 55	5 13 26	1 29 16	5 13 10	5 35 0
	9 13 56		8 57 4		
	1 54 57	5 55 42	2 10 19	5 55 52	5 57 0
	9 56 27		9 41 26		
4	1 32 24	5 47 13	1 46 12	5 46 50	6 20 0
	10 2 2		9 47 27		
	2 36 42	6 11 5	2 53 2	6 16 34	6 28 0
	9 45 28		9 40 7		
5	2 57 50	6 33 10	3 10 10	6 32 1	6 43 0
	10 8 29		9 53 52		
	2 34 38	6 30 32	3 51 6	6 59 50	7 13 0
	10 26 25		10 8 35		
6	3 14 20	7 4 47	3 26 31	7 3 50	7 34 0
	10 55 14		10 41 8		
	3 56 36	7 33 48	4 10 17	7 33 33	7 45 0
	11 11 0		10 56 48		
7	3 57 13	7 47 54	4 11 22	7 48 2	8 3 0
	11 38 34		11 24 43		
	4 15 50	7 59 59	4 38 30	8 4 28	8 24 0
	11 44 8		11 30 27		
8	4 45 40	8 23 44	4 59 54	8 22 59	8 43 0
			11 46 4		
	0 1 48				
	5 13 15	8 47 3	5 26 50	8 45 27	9 0 0
9	0 20 51		0 4 3		

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
February 9	0 20 51		0 4 3		
	5 14 10	9 0 48	5 29 7	8 59 54	9 17 0
	0 47 26		0 30 40		
	5 38 9	9 23 45	5 54 48	9 25 15	9 30 0
10	1 9 20		0 55 42		
	5 50 17	9 40 9	6 5 0	9 36 50	10 0 0
	1 30 0		1 8 40		
	6 25 2	10 8 16	6 46 3	10 6 47	10 16 0
11	1 51 31		1 27 30		
	6 32 50	10 27 52	6 56 40	10 27 55	10 46 0
	2 22 54		1 59 11		
	6 56 12	11 3 13	7 17 40	10 56 20	11 12 0
12	3 10 15		2 35 0		
	7 24 30	11 36 24	7 58 0	11 35 39	11 42 0
	3 48 18		3 12 37		
	8 29 35	0 33 25	9 5 10	0 33 59	0 25 0
13	4 37 15		4 2 48		
	9 23 34	1 17 2	9 56 19	1 18 34	1 20 0
	5 10 30		4 40 50		
	10 5 15	2 4 54	10 37 20	2 6 48	1 59 0
14	6 4 32		5 36 16		
	11 7 48	2 51 44	11 31 2	2 50 19	2 54 0
	6 35 40		6 9 35		
	11 38 2	3 26 17	11 58 36	3 26 11	3 35 0
15	7 14 34		6 53 45		
	0 22 3	4 1 4	0 41 42	4 0 59	4 16 0
	7 40 5		7 20 16		
16	0 43 20	4 24 18	1 0 45	4 25 27	4 39 0
	8 5 15		7 50 9		
	1 21 25	4 58 28	1 38 3	4 58 10	5 10 0
	8 35 39		8 18 16		
17	1 35 10	5 15 44	1 56 16	5 18 49	5 28 0
	8 56 17		8 41 22		
	2 11 52	5 44 11	2 27 21	5 44 23	5 50 0
	9 16 30		9 1 25		
18	2 23 44	6 1 36	2 37 14	6 1 31	6 11 0
	9 39 28		9 25 47		
	2 59 2	6 23 39	3 13 9	6 24 24	6 34 0
	9 48 15		9 35 40		
19	3 9 9	6 40 23	3 23 43	6 40 54	6 52 0
	10 11 36		9 58 6		
	3 36 45	7 0 41	3 51 29	7 0 36	7 12 0
	10 24 36		10 9 42		
20	3 35 20	7 8 55	4 0 24	7 14 3	7 30 0
	10 42 29		10 27 43		
	4 7 28	7 33 49	4 22 4	7 29 17	7 43 0
	11 0 10		10 36 30		
21	4 13 12	7 43 37	4 29 25	7 43 46	7 59 0
	11 14 2		10 58 8		
	4 34 50	7 59 42	4 49 20	7 58 30	8 10 0
	11 24 33		11 7 40		
22	4 38 2	8 12 57	4 52 18	8 12 23	8 22 0
	11 47 52		11 32 28		
	4 55 0	8 26 10	5 9 10	8 23 8	8 41 0
	11 57 20		11 37 5		
23	5 2 0		5 17 55		

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
February 23	5 2 0 0 12 30	8 37 15	5 17 55 11 50 45	8 34 20	8 52 0
24	5 15 12 0 34 43	8 54 58	5 35 20 0 25 10	9 0 15	9 2 0
	5 24 12 0 41 28	9 2 50	5 44 50 0 15 18	9 0 4	9 20 0
25	5 40 47 0 53 52	9 17 20	5 59 4 0 23 12	9 11 8	9 31 0
	5 50 4 1 8 42	9 29 23	6 15 0 0 39 3	9 27 2	9 45 0
26	6 6 25 1 37 50	9 52 7	6 33 15 0 57 10	9 45 13	10 0 0
	6 26 20 1 53 17	10 9 49	6 58 15 1 4 54	10 1 35	10 31 0
27	6 59 0 2 48 50	10 53 55	7 51 40 1 49 32	10 50 36	10 57 0
	7 41 53 3 56 6	11 49 0	8 45 48 2 42 28	11 44 8	11 42 0
28	8 30 5 4 53 16	0 41 41	9 25 50 4 5 34	0 45 42	0 30 0
	10 2 30 5 37 52	1 50 11	10 47 57 4 51 10	1 49 34	1 5 0
29	10 32 6 6 5 0	2 18 33	11 9 21 5 30 27	2 19 54	2 0 0
	11 29 26 6 34 15	3 1 50	0 0 44 6 1 17	3 1 4	2 46 0
March 1	11 45 0 6 55 30	3 20 15	0 17 20 6 30 20	3 23 50	3 24 0
	0 30 4 7 15 53	3 52 59	0 58 0 6 51 10	3 54 35	4 0 0
2	0 42 50 7 40 16	4 11 33	1 2 25 7 19 48	4 11 2	4 23 0
	1 14 12 8 5 35	4 39 54	1 35 28 7 50 14	4 42 51	4 48 0
3	1 25 40 8 24 25	4 55 8	1 43 17 8 7 12	4 55 15	5 7 0
	1 58 27 8 42 20	5 20 24	2 14 49 8 20 5	5 17 27	5 31 0
4	2 9 50 9 3 20	5 36 55	2 24 45 8 48 8	5 36 27	5 53 0
	2 40 1 9 23 30	6 1 46	2 54 9 9 3 55	5 59 2	6 10 0
5	2 47 42 9 47 18	6 17 30	2 54 21 9 35 7	6 14 44	6 32 0
	3 5 57 10 4 6	6 35 2	3 19 1 9 51 5	6 35 3	6 50 0
6	3 19 21 10 24 10	6 51 46	3 31 34 10 10 29	6 51 2	7 6 0
	3 45 59 10 35 45	7 10 52	3 58 47 10 21 30	7 10 9	7 23 0
7	3 59 0 10 58 37	7 28 49	4 12 47 10 44 38	7 28 43	7 42 0
	4 22 24 11 9 35	7 46 0	4 36 1 10 55 2	7 45 32	7 58 0
8	4 34 41		4 45 15		

Table. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
March 8	4 34 41	8 2 56	4 45 15	8 0 44	8 15 0
	11 31 11		11 16 12		
	4 57 31	8 21 12	5 12 28	8 21 22	8 39 0
	11 44 52		11 30 15		
9	5 15 14		5 29 58	8 38 54	8 51 0
		8 40 10	11 47 50		
	0 5 5		5 32 42		
	5 49 19	9 5 37		8 48 5	9 16 0
10	0 21 55		0 3 28		
	5 53 55	9 19 19	6 11 40	9 17 27	9 36 0
	0 44 43		0 23 14		
	6 8 17	9 39 24	6 27 57	9 37 56	9 51 0
11	1 10 30		0 47 54		
	6 37 51	10 7 50	7 2 14	10 4 36	10 22 0
	1 37 49		1 6 57		
	7 3 20	10 34 48	7 30 25	10 35 14	10 48 0
12	2 6 15		1 40 3		
	7 53 4	11 28 48	8 27 29	11 26 41	11 25 0
	3 4 31		2 25 53		
	8 27 10	0 12 43	9 3 40	0 17 2	0 24 0
13	3 58 16		3 30 23		
	9 53 2	1 24 9	10 28 32	1 24 25	1 18 0
	4 55 16		4 20 18		
	10 12 35	1 58 34	10 40 37	1 56 26	2 0 0
14	5 44 33		5 12 14		
	11 21 32	2 51 31	11 47 30	2 49 0	2 50 0
	6 21 30		5 50 29		
	11 28 15	3 7 43	11 55 6	3 10 23	3 27 0
15	6 47 10		6 25 40		
	0 26 25	3 54 38	0 50 30	3 54 25	3 56 0
	7 22 51		6 58 20		
16	0 40 15	4 11 11	1 0 40	4 12 39	4 25 0
	7 42 6		7 24 37		
	1 17 20	4 41 42	1 35 19	4 41 17	4 50 0
	8 6 3		7 47 15		
17	1 32 9	4 58 49	1 46 40	4 58 26	5 6 0
	8 25 28		8 10 11		
	1 59 32	5 14 56	2 15 6	5 14 38	5 32 0
	8 30 20		8 14 10		
18	2 8 42	5 36 44	2 22 54	5 36 29	5 46 0
	9 4 36		8 50 3		
	2 33 15	5 56 56	2 48 8	5 58 2	6 9 0
	9 20 37		9 6 57		
19	2 39 20	6 8 54	2 49 35	6 6 49	6 21 0
	9 38 28		9 24 2		
	3 4 34	6 27 37	3 19 7	6 27 9	6 43 0
	9 50 40		9 35 10		
20	3 12 20	6 38 56	3 30 40	6 41 0	6 55 0
	10 5 32		9 51 19		
	3 34 15	6 57 25	3 48 21	6 56 46	7 7 0
	10 20 35		10 5 10		
21	3 38 24	7 7 4	3 52 30	7 6 26	7 17 0
	10 35 44		10 20 22		
	3 57 13	7 22 2	4 12 52	7 21 4	7 32 0
	10 46 50		10 29 16		
22	4 10 50		4 26 55		

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
March 22	4 10 50		4 26 55		
	10 59 35	7 35 13	10 40 30	7 33 43	7 42 0
	4 25 10		4 40 50		
	11 10 15	7 47 43	10 55 4	7 47 57	7 58 0
23	4 34 20		4 51 21		
	11 24 42	7 59 31	11 4 28	7 57 55	8 10 0
	4 44 38		5 2 18		
	11 37 9	8 10 54	11 15 32	8 8 55	8 23 0
24	5 4 30		5 27 15		
	11 43 34	8 24 2	11 18 20	8 22 48	8 38 0
	5 10 49		5 32 24		
		8 36 15	11 32 35	8 32 30	8 49 0
25	0 1 40		5 53 20		
	5 28 10		11 27 27	8 40 24	9 0 0
	0 3 1	8 45 36	6 9 30		
	5 42 34			9 4 46	9 20 0
26	0 36 20	9 9 27	0 0 1		
	6 5 25		6 35 41		
	0 55 51	9 30 38	0 11 39	9 23 40	9 44 0
	6 17 10		6 56 20		
27	1 42 15	9 59 43	0 52 23	9 54 22	10 19 0
	7 16 5		8 17 35		
	2 43 48	10 59 57	1 44 13	11 0 54	11 4 0
	7 45 0		8 46 50		
28	3 29 50	11 37 25	2 33 10	11 40 0	0 3 0
	9 36 19		10 25 43		
	4 45 2	1 10 41	3 58 40	1 12 12	0 41 0
	9 46 49		10 25 17		
29	5 18 10	1 32 30	4 42 55	1 34 6	1 26 0
	10 44 15		11 15 20		
	5 55 10	2 19 43	5 24 20	2 19 50	2 11 0
	10 58 30		11 26 11		
30	6 18 25	2 38 28	5 53 11	2 39 41	2 48 0
	11 45 2				
	6 48 11	3 16 37	0 7 13		
	11 55 39		6 24 15	3 15 44	3 24 0
31	7 8 30	3 32 5	0 14 10		
			6 49 20	3 31 45	3 42 0
	0 33 49		0 52 31		
	7 33 5	4 3 27	7 14 0	4 3 16	4 16 0
April 1	0 45 0		1 0 13		
	7 57 31	4 21 16	7 41 14	4 20 44	4 39 0
	1 13 3		1 28 8		
	8 24 45	4 48 54	8 9 16	4 48 42	5 0 0
2	1 24 10		1 39 11		
	8 42 59	5 3 35	8 28 43	5 3 57	5 19 0
	1 54 8		2 8 21		
	8 58 15	5 26 12	8 41 53	5 25 7	5 39 0
3	2 4 12		2 23 30		
	9 21 8	5 42 40	9 8 22	5 45 56	5 56 0
	2 38 54		2 52 30		
	9 36 38	6 7 46	9 23 15	6 7 52	6 14 0
4	2 56 44		3 9 52		
	9 58 32	6 27 38	9 45 22	6 27 37	6 34 0
	3 18 58		6 31 59		
	10 13 5	6 46 2	9 59 14	6 45 37	6 58 0
5	3 38 16		3 52 21		
	10 35 20	7 6 48	10 20 10	7 6 16	7 12 0

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
April 5	3 58 15 10 51 25	7 24 50	4 11 12 10 36 45	7 23 59	7 34 0
6	4 17 5 11 18 40	7 47 53	4 31 12 11 3 44	7 47 27	7 54 0
	4 29 58 11 36 10	8 3 4	4 44 26 11 22 44	8 3 35	8 10 0
7	4 49 15 11 55 49	8 22 32	5 6 14 11 35 38	8 20 56	8 33 0
	5 16 28 11 58 10	8 37 19	5 33 42 11 47 15	8 40 29	8 54 0
8	5 47 28 0 40 3	9 13 51	6 7 6 0 17 18	9 12 12	9 19 0
9	6 6 20 1 5 24	9 35 52	6 27 30 0 35 43	9 31 37	9 41 0
	6 50 20 1 27 55	10 9 8	7 17 40 0 52 41	10 5 11	10 14 0
10	7 5 20 2 11 22	10 38 26	7 32 40 1 40 20	10 36 30	10 54 0
	8 10 43 2 59 32	11 35 8	8 48 47 2 21 3	11 34 55	11 39 0
11	8 34 52 3 46 8	0 10 30	9 5 59 3 13 10	0 9 35	0 11 0
	9 52 9 4 43 2	1 17 36	10 22 48 4 10 19	1 16 34	1 14 0
12	10 8 22 5 21 37	1 45 0	10 33 57 4 55 44	1 44 51	1 48 0
	10 59 0 6 5 10	2 32 5	11 18 14 5 39 16	2 28 45	2 36 0
13	11 16 33 6 24 10	2 50 22	11 38 28 6 5 42	2 52 4	3 6 0
	0 1 29 6 58 23	3 29 56	0 20 58 6 36 50	3 28 54	3 38 0
14	0 9 25 7 18 27	3 43 56	0 29 50 7 1 14	3 45 32	3 57 0
	0 44 34 7 43 15	4 13 55	1 1 36 7 24 30	4 13 3	4 24 0
15	0 58 29 8 2 48	4 30 39	1 9 32 7 45 53	4 27 43	4 39 0
	1 21 37 8 19 45	4 50 41	1 36 56 8 3 13	4 50 5	4 58 0
16	1 36 18 8 33 37	5 4 58	1 50 43 8 18 4	5 4 24	5 16 0
	1 59 52 8 42 37	5 21 15	2 15 19 8 32 18	5 23 49	5 36 0
17	2 14 50 9 7 40	5 41 15	2 29 55 8 51 20	5 40 38	5 54 0
	2 33 38 9 18 20	5 55 59	2 50 14 9 2 10	5 56 12	6 9 0
18	2 45 41 9 37 23	6 11 32	2 59 53 9 21 57	6 10 55	6 22 0
	2 59 9 9 53 34	6 26 22	3 14 5 9 38 45	6 26 25	6 37 0
19	3 12 15 10 8 17	6 40 16	3 22 11 9 51 15	6 36 43	6 48 0
	3 21 40 10 23 18	6 52 29	3 38 10 10 4 51	6 51 31	7 5 0

TABLE. (Continued.)

	M. ft. in. 9 10	Calculated High Water from M.	N. ft. in. 10 10	Calculated High Water from N.	Observed High Water.
1840.	h m s	h m s	h m s	h m s	h m s
April 20	3 40 52 10 32 46	7 6 49	3 57 3 10 14 3	7 5 32	7 13 0
	3 51 52 10 43 55	7 17 54	4 6 53 10 25 26	7 16 10	7 29 0
21	4 8 46 10 58 18	7 33 32	4 27 8 10 36 52	7 32 1	7 48 0
	4 15 20 11 13 21	7 44 21	4 33 4 10 51 43	7 42 24	7 59 0
22	4 41 20 11 23 52	8 2 36	5 2 6 10 59 1	8 0 34	8 18 0
	4 42 2 11 45 40	8 13 51	5 2 42 11 20 15	8 11 29	8 28 0
23	5 12 20 11 58 8	8 35 14	5 32 12 11 22 24	8 27 18	8 45 0
24	5 18 23 0 26 50	8 52 37	5 41 29 11 54 35	8 48 2	9 5 0
	5 45 7 0 46 20	9 15 44	6 15 50 0 8 17	9 12 4	9 31 0
25	5 49 29 1 26 47	9 38 8	6 21 11 0 48 5	9 34 38	9 53 0
	6 48 45 2 17 36	10 33 11	7 30 10 1 33 16	10 31 43	10 38 0
26	6 58 30 2 50 12	10 54 21	7 42 10 2 5 8	10 53 39	11 11 0
	8 39 10 3 39 55	0 9 33	9 24 30 2 55 58	0 10 14	0 5 0
27	9 0 5 4 17 10	0 38 38	9 48 12 3 45 20	0 46 46	0 40 0
	9 58 31 5 2 43	1 30 37	10 26 15 4 34 9	1 30 12	1 33 0
28	10 10 41 5 20 11	1 45 26	10 36 16 5 1 45	1 49 0	2 6 0
	11 3 24 5 56 16	2 29 50	11 26 27 5 31 59	2 29 13	2 39 0
29	11 21 18 6 17 55	2 49 37	11 44 54 5 54 52	2 49 52	3 7 0
	11 59 20 6 48 36	3 23 58	0 19 0 6 29 5	3 24 3	3 33 0
30	0 12 30 7 10 5	3 41 38	0 28 16 6 54 41	3 41 29	3 54 0
	0 45 16 7 35 40	4 10 28	1 1 22 7 20 15	4 10 49	4 22 0